O&M and asset management 2.0: optimising the sector through digitalisation

Operations & maintenance | New technologies are helping revolutionise the management and profitability of PV power plants. Martina Pianta, Guillermo Oviedo Hernández, Constantinos Peonides, Will Hitchcock and Máté Heisz look at some of the digital innovations helping advance the deployment solar energy in Europe and beyond

Credit: Above

The use of drones is just one of the innovations helping drive forward the sophistication of solar O&M and asset management

In a post-subsidy era and as assets increase in size, pressure on the lifecycle cost of utility-scale solar has intensified. From development through to operations and maintenance (O&M), it is widely accepted that the industry needs to embrace digitalisation and technology to increase efficiency and automation across all stages of the asset's life.

In order to meet the 2030 EU climate targets, member states are committed to increasing electricity generation from renewable resources. One of the most effective ways forward, from an ecological and economic point of view, involves improving the actual performance, and reducing the operational costs, of existing renewable power plants. An effective strategy for achieving this goal is the application of digitalisation techniques – including artificial intelligence (AI), data mining, drone operation and robotics – to convert the immense amount of data that these plants generate into information that can be used to make optimised operational decisions.

Data mining and AI are creating a smarter sector

The potential of data mining algorithms to optimise performance and reduce operational costs is widely demonstrated, provided that the data is of high quality and granularity, and is consistent, robust and processed within the proper system model framework. The impact of this approach to managing renewable portfolios goes beyond the immediate benefit of fully exploiting the capacity of the plant, and further facilitates an overall increase of profits (via a decrease in levelised cost of energy, LCOE), and the mitigation of certain operational risks. This will ultimately attract more investments – both for renewable projects and grid infrastructure – generating a virtuous circle that will trigger new capacity deployment and a higher penetration of renewables in the energy mix.

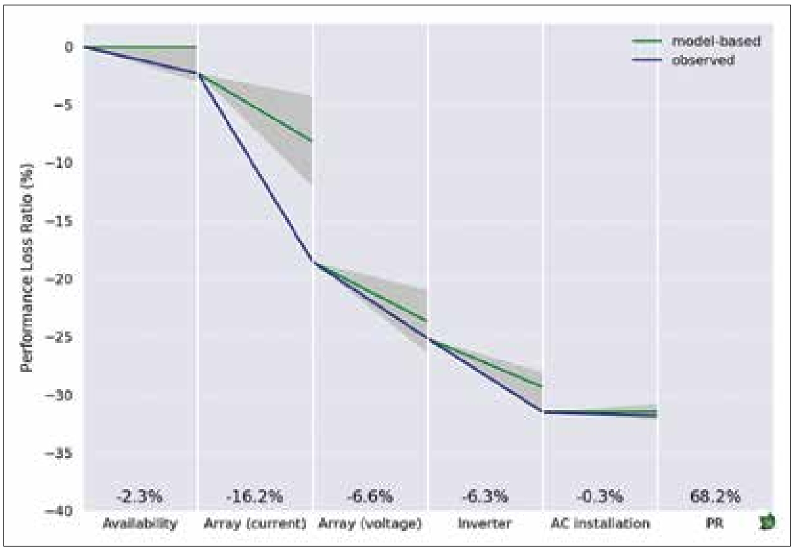
Predictive maintenance

Predictive maintenance through data mining consists in retrieving vast amounts of data from one or more sources and combining them with the aim of understanding ongoing anomalies and predicting the future behaviour of linked devices. Big data analytics can bring added value at any stage of asset management: from observation of collected information to fault detection, fault diagnosis and finally optimisation through recommendations. Today, different approaches are proposed. Whereas classic AI proposes advanced diagnostic through knowledge-based models, unsupervised and supervised learning methods offer different possibilities (e.g. neural networks) using statistical approaches.

The benefits of predictive maintenance include reducing plant losses and optimising plant performances. Exploiting high-frequency data sent from the site, combined with a detailed model of the installed system, can enable operators to analyse the plant's condition, leading to an immediate and effective decision that requires nearly no time. Thanks to current data-mining techniques, asset operators can easily make decisions on the most effective way of performing their daily operations and maintenance activities, improving the performance of the portfolio and anticipating failures of the devices composing these complex systems.

Predictive maintenance techniques have undergone rapid developments in recent years. Monitoring and performance platforms can combine independent monitoring and data collection with the most reliable performance analysis algorithms in the PV industry.

A carpet analysis of all available asset data, associated with a well-known set of parameters of the site and consistent algorithms, is used by advanced monitoring and automated diagnostics tools. These tools apply a full loss root



Credit: 3E

Figure 1. Modelled versus observed PR degradation in PV power plant

cause analysis based on the comparison of expected losses (the so-called "digital twin") and actual losses, for each conversion step. In this way, targeted recommendations for immediate or mid-term actions drive performance optimisation by a sensitive reduction of device downtime and underperformances. Additionally, a smoother planning of activities and a better device replacement scheduling reduce hardware and operational costs.

The waterfall diagram in Figure 1 is an example showing the PR degradation of one plant for each conversion step. In this case, the operator can easily focus his attention on the main event that creates the higher PR losses (in this case the DC current) and then drill down into the data to investigate the problem in further detail, understanding how long it has been occurring and evaluating possible root causes.

Cloud computing

The key to an effective management of renewable assets and portfolios consists in an easily accessible platform, built with open architecture, which enables users to receive, store and process data from different kinds of on-site devices and data from other varieties of external platforms.

Cloud computing serves this purpose by managing a large amount of data coming from on-site devices, and by collecting and sending information to and from the grid, relaying operational dispatching and contract management data in real time over the internet. Cloud computing is typically available online via most browsers and does not require the installation of local software, while computing resources are shared in a network.

Beyond the initial phase of configuration and customisation necessary to connect to the multiple data sources, cloud computing has the certain benefit of reducing all efforts in collecting and aggregating data to produce meaningful information for any user.

On-demand, scalable and accessible from any device with internet access, it serves as a communication and collaborative set of tools that ultimately reduces the cost of operations and enhances the efficiency of plant management.

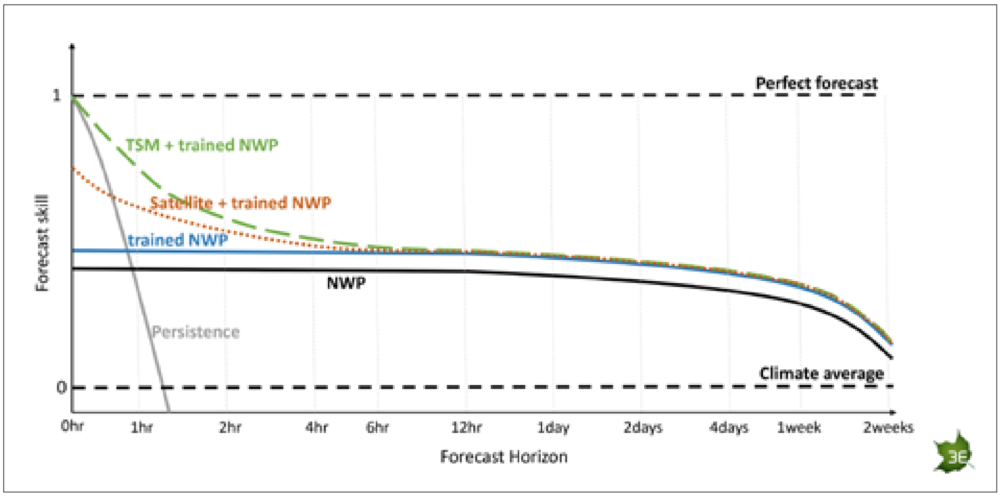
Combining these different data sources in a transparent and open way implies the need for interoperability. Modern portfolios rely on connecting and enabling the interaction between different devices, applications and services to serve their intrinsic diversification, paving the way for the creation of Platforms as a Service (PaaS).

PaaS encompass the advantages of cloud computing over different applications and serve as a unique interface layer for all underlying services around the photovoltaic business, from the operational to the administrative level.

Remote sensing and control

The share of renewable generation in the energy market is growing, expected to reach 30% of overall energy demand by 2030. The major challenge within this new composition is given by the unpredictability of energy availability, where an important lack or excess of energy would lead to a collapse of the grid and consecutive blackouts.

Detailed information from the site coupled with a precise model and accurate solar resource forecast allows for efficient



Credit: 3E

Figure 2. A combination of forecasts can lead to more precise results

prediction of the expected performance of a photovoltaic asset. By coupling this information with the expected need from the grid operator, an advanced monitoring system is capable of communicating to on-site devices the best operational behaviour to adopt to avoid grid stress.

Reaching a steady balance for the grid is the first benefit of this approach; however, the combination of remote sensing and control with a storage system (local or performed by an aggregator) allows for further advantages for the energy producer and end user. First, being able to store the energy when it is not manageable by the grid represents a better option than capping the PV plant output, or worse, shutting it down. Furthermore, the combination of energy price fluctuations and the ability to modulate the energy sent to the grid gives the energy producer the possibility of extracting the highest value from the energy produced.

Direct control of the plant by the DSO or an aggregator is one of the ways to manage the modulation of the produced power to fit to the grid capacity. Other techniques foresee the automatic derating of PV plants through full automation. However, this has not yet been fully implemented. In several EU countries, the regulation is heading in the direction of prediction of intraday and day-ahead production for a better power balance.

An increasing need for energy forecasting

In a context where renewables make up an important share of the energy market, one of the major challenges that the sector continues to face is energy management, which is complicated by the variability of renewable generation. The accurate forecasting of both load and production combined with sophisticated market pricing mechanisms (e.g. negative prices and negative control energy) can help the sector to overcome this difficulty. Further, it is important that operational insights (i.e. plant monitoring and O&M scheduling) are cultivated and disseminated so as to result in the best-in-class intra-day and day-ahead prediction of plant energy production.

Assessing the irradiation of a PV plant is crucial to successful operations. Depending on the time forecast horizon, a combination of forecasts based on Numerical Weather Prediction (NWP) models and advanced time-series models (TSM) can lead to precise results. Today, state-of-the-art technologies in this field can provide intra-hour to day-ahead forecasting with Mean Absolute Error (MAE) values ranging in the order of ±4% (normalised to the installed capacity of the PV plant), depending on region (weather conditions), and on-site data availability and quality as input for training algorithms.

The second important component of optimised forecasting is the estimation of plant performance given the irradiance conditions. A data mining tool, encompassing all plant boundary conditions – such as components datasheet, layout, installation date, components temperature, estimated degradation – would ultimately provide a consistent indication of forecasted energy. This would involve only a small uncertainty, in the order of ±2%, in the best-case scenario when all plant conditions are well known with high granularity details, and the information is updated at each moment by the O&M team.

A final component of uncertainty includes the unforeseeable events, such as grid unavailability or component failure, that would change the forecasted energy output with the most significant variance.

Component failure can be somewhat foreseen with advanced data mining tools; however, the precision of these methods is highly dependent on information that the hardware can provide to the data mining tool. A standardisation of signals emitted by PV component devices would be required for an optimal and predictable system.

There are at least three advantages of such an energy forecasting system. First, this would result in optimised planning for O&M activities. Awareness of meteorological conditions and plant performance in advance, combined with forecasted energy pricing, would allow for an easier trade-off between switching off production and servicing the site. Second, energy forecasting allows for optimised storage needs by managing the charge and discharge of energy accumulators. Third, these tools allow the highest value of produced energy to be harnessed through an optimised energy trading intelligence. Through the proper usage of day-ahead and intra-day forecasting services, an operator can reduce transaction risks and effectively balance costs.

Field work of the future

In the present highly competitive PV sector, price pressure is forcing O&M contractors to increase plant performance and energy yield while minimising operation costs. To tackle this challenge, in markets where the full-time presence of technicians on-site is unaffordable, the adoption of digital solutions for the optimisation of field interventions is becoming an imperative.

Digital technologies are already providing great benefits in areas such as plant monitoring, asset management, yield forecasting and aerial thermographic inspections. Highly automatised control rooms are replacing time-consuming methods of spreadsheet-based calculations by advanced analytics and O&M-specific software, which, along with the use of AI engines, promise to enhance efficiency in dispatching.

But field operations have somehow lagged behind. State-of-the-art technologies barely go beyond assisted scheduling and remote support via email or telephone. Despite fully digital ticketing systems being in place, the daily activities of field workers have not changed much in the past decades. This becomes even more evident when troubleshooting activities force the allocation of valuable resources to solve urgent issues – for instance, by deploying highly qualified personnel on-site.

In the European market, we have seen an increase in the efficiency of technicians, not only due to increased education and up-skilling, but also thanks to the widespread use of IT technologies. However, in some regions where plants are small (e.g. 1MWp) and spread over a large territory, the number of technicians required to service the managed portfolio is still large. Furthermore, additional challenges may arise when dealing with old PV plants that have surpassed their mid-life point and are getting closer to end-of-life, where the deployment of state-of-the-art monitoring and SCADA systems is often not feasible (for obvious financial reasons) and therefore, field workers cannot always benefit from the innovations coming from modern IT.

Nevertheless, in the mid-term, for new large-scale portfolios, it is envisioned that field workers will fully benefit from more interconnected digital ecosystems. For example, IoT and industry 4.0 solutions will enable the digital recreation of PV plants (3D digital twins), where each single component will be geo-referenced and will become a fully manageable digital entity. In this landscape, a field technician equipped with a smart device (e.g. smartphone or tablet) will be able to locate the components of the plant that need maintenance or repair. Furthermore, just by selecting the component of interest on the screen, it will be possible to record (e.g. upload pictures) and document the operations performed. Then, that data would be automatically uploaded and categorised into a database, which will process and analyse it in order to support the decision-making process with indications of the necessary operations to be performed in terms of predictive maintenance. Additionally, solutions such as helmets powered by augmented reality will provide field workers with real time remote assistance by expert service engineers, who can guide them through specialised technical interventions without the need to be on site.

How drones help the sector to soar

Over the past few years, the use of drones in the solar industry has moved from a novelty to a mainstream technique. Initially seen as a gimmick with questionable value, drones are now fulfilling key roles across the entire asset life cycle.

In the early planning stages, the use of drones for topographical surveying provides a faster, lower cost and more useful output than that of traditional surveying techniques. Using either Lidar or photogrammetry, the drone can survey large areas quickly and accurately to assess the viability of potential installation sites. Drone topography accuracy is high, and the resulting shading model increases confidence in the yield calculation, thus resulting in more informed decision making.

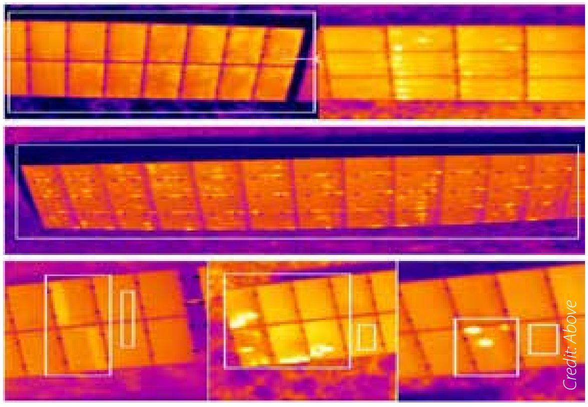


Figure 3. The detection of problems such as PID is just one of the many functions drones can perform in PV power plant management

During the construction phase, drones are used for construction monitoring, which, for larger assets, is a valuable addition to security and stock management as well as project status reporting. However, it is during the commissioning phase that the drone can add the most value – using photogrammetry, it is possible to produce a highly accurate 3D model of a solar asset. This not only generates detailed 'as-built' CAD drawings based on real-world data but can also be used to assess the asset's external, internal and self-shading profile to validate the reference yield calculation; a valuable addition to technical due diligence and vital when considering the reference yield's onward impact on the PR figure and its influence over commercial decision making.

The use of drones for thermal imaging has quickly become an industry standard. Drones are transforming the way in which technicians validate an asset's electrical integrity, in an industry previously reliant on manual string measurements and random ground-based thermography. Aerial thermography provides a complete picture of the asset down to a cellular level. This low-cost and highly accurate technique helps prevent early yield and revenue loss by identifying quality, construction and commissioning issues in their early stages. Thermal imaging conducted at PAC provides an early health baseline for all modules. In addition to a comprehensive plan for the EPC to resolve any identified issues ahead of IAC or FAC, when a second thermographic inspection should be conducted.

Advances in software allow for the integration of all types of aerial data with other inspection, testing and monitoring data to create a digital twin of the solar plant. This provides the industry with a robust platform to monitor plant health, chart degradation and manage issues. Early identification of issues and degradation leads to a faster response time, more efficient use of resources and, ultimately, a more productive and financially viable asset. Development in drone technology, sensors, AI and computer vision will continue to increase the value they bring to the solar sector, playing an important step in the journey to net-zero.

Lifecycle asset management can optimise solar projects

As the solar sector becomes increasingly globalised, with service expectations requiring cost reduction and revenue optimisation, asset managers are beginning to rely on advanced digital asset management platforms that enable efficient and effective management of diverse solar portfolios.

The asset manager is a key position in the solar power plant's lifecycle: from development, through construction and operation, to decommissioning and disposal. By focusing on the operational phase – the longest phase of the project lifecycle – it becomes clear that lifecycle project management is crucial to the success of solar projects.

Throughout the lifecycle of the solar plant the asset manager oversees a number of core competencies across technical, financial and contractual functions. Stage-gate management involves the asset manager ensuring that at transitions between milestones, the required documentation associated with risk management, value protection and performance is validated and stored. Documentation management requires the asset manager to ensure that an index mechanism exist for the storage, version control and retrieval of static and dynamic documents that underpin the value of the plant.

Risk management demands a comprehensive approach with the asset manager tracking key risks throughout all project phases. Asset managers are recommended to request the certification of power plants through their lifecycle to international standards via available international certification schemes or conformity assessment systems.

During the operational phase, the asset manager's responsibilities are myriad. EPC contractors usually provide a two-year performance warranty period after the commercial operation date (COD), during which it is the responsibility of the asset manager to monitor, calculate and report the values of Performance Ratio and other KPIs guaranteed by the EPC contractor. In this context, the asset manager is responsible for managing the interventions completed within the scope of the warranty in order to safeguard the performance commitments undertaken under the contract; informing the asset owner about the condition of the contracted performance indicators; and alerting the asset owner whenever the levels of the indicators have values or tendencies that could indicate a risk of failure. All these activities require the asset manager to pre-empt issues of equipment life expectancy through the effective management of an asset register.

Further, the management of data throughout the lifecycle can be facilitated by digital platforms. Asset managers should make use of an asset management platform that can undertake some or all the digital aspects in order to consolidate all relevant information. Advanced data analysis services come in many forms, with the most sophisticated using special algorithms including machine learning for exploring big data. Service providers with experience and knowledge in the solar industry can combine this with digital analytics to transform data into intelligence. The use of this software can help asset managers identify problem areas, as well as reduce costs through comprehensive plant data. Indeed, the act of plant monitoring itself is being increasingly automated, simplifying overall reporting documentation.

In all these cases, comprehensive lifecycle asset management in tandem with the latest digital service platforms can optimise all phases of development of the solar power plant.

Making a 'mark' on O&M and asset management

As the global energy landscape is changing, new rules and regulations are introduced and established. In this environment, the necessity emerged for operations & maintenance best practices guidelines, in order to standardise procedures across the board without geographical boundaries.

Since its inception in 2016, the O&M guide has evolved (already in its fourth version) into a comprehensive document, with each new version addressing the newest market trends and requirements. The main topics of the guidelines include environment, health and safety, training of personnel, plant operation and maintenance, revamping and repowering, data monitoring, and contracts.

To emphasise the importance and value of the guidelines, an O&M best practices 'mark' was developed. This is a self-assessed mark that O&M service providers can obtain by adhering to and following the guidelines. The mark is an indication of excellence, with two key benefits: (1) internally, as it is self-assessed, it helps organisations re-evaluate, re-engineer, and transform their processes in order to become more transparent and efficient; (2) externally, for asset owners looking to outsource O&M service activities, the mark helps them select the best third-party independent service providers.

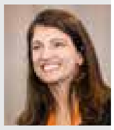
As the industry continues to evolve into a global marketplace, with investors showing greater interest in widely dispersed portfolios, it became clear that best practice guidelines were required for a role that is becoming more important across sectors: that of asset management. This role involves supervising O&M service providers and the quality of service they are delivering according to the contract and standards that they have agreed on with the asset owners, as well as adhering to all statutory legal tasks and other requirements that relate to the financial management of assets.

The first version of the "Asset Management Best Practice Guidelines" is currently being prepared. The document will outline the best practices of the industry and set a new global standard. As the PV sector becomes more and more globalised and decentralised, the need for standards such as these becomes more and more important.

SolarPower Europe's O&M guide has a proven track record, helping the sector to ensure a high level of quality and consistency. The O&M best practices mark will provide further guidance to contractors, investors, asset managers and all interested stakeholders all over the world. The forthcoming asset management guidelines will fill a crucial gap, supporting the sector to deliver cutting-edge, cost-efficient and future-proof services that will allow solar to continue its growth trajectory.

With the European demand for solar increasing by 80% in 2019, adding 20.4GW of installations, and forecasted installations for 2020 currently sitting at 24.1GW, the EU remains a world-leader in the climate transition. SolarPower Europe is committed to providing clear O&M and asset management guidelines in order to support this very necessary growth.

Authors



Martina Pianta is the product manager at 3E for SynaptiQ, a performance monitoring platform. Through SynaptiQ, she strives to help O&M and asset managers to reach plant performance excellence. Martina has more than 10 years of experience in the renewable energy sector and has been an active member of SolarPower Europe's O&M and Asset Management Task Force since 2016.

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Will Hitchcock is founder and CEO of Above, a pioneer in the use of aerial inspections, digitalisation and data analytics within the utility-scale solar sector. With a bachelor's in engineering, he has extensive commercial, IT and engineering experience. During 2014-2015, as programme director at Push Energy, he constructed 150MW of ground-mounted solar. Will is a chartered environmentalist and in 2011 co-founded the UK's first community-owned solar co-operative, Green Energy Nayland.

Máté Heisz is the head of international cooperation at SolarPower Europe and coordinator of the body's Emerging Markets and Operations & Maintenance and Asset Management task forces. Prior to joining SolarPower Europe in February 2017, he spent four years in Tunisia working as a renewable energy advisor at the Tunisian Ministry of Energy on behalf of the German Development Cooperation (GIZ). Máté holds a master's degree in international relations from the Free University of Berlin and a master's degree in economics from the Corvinus University of Budapest.